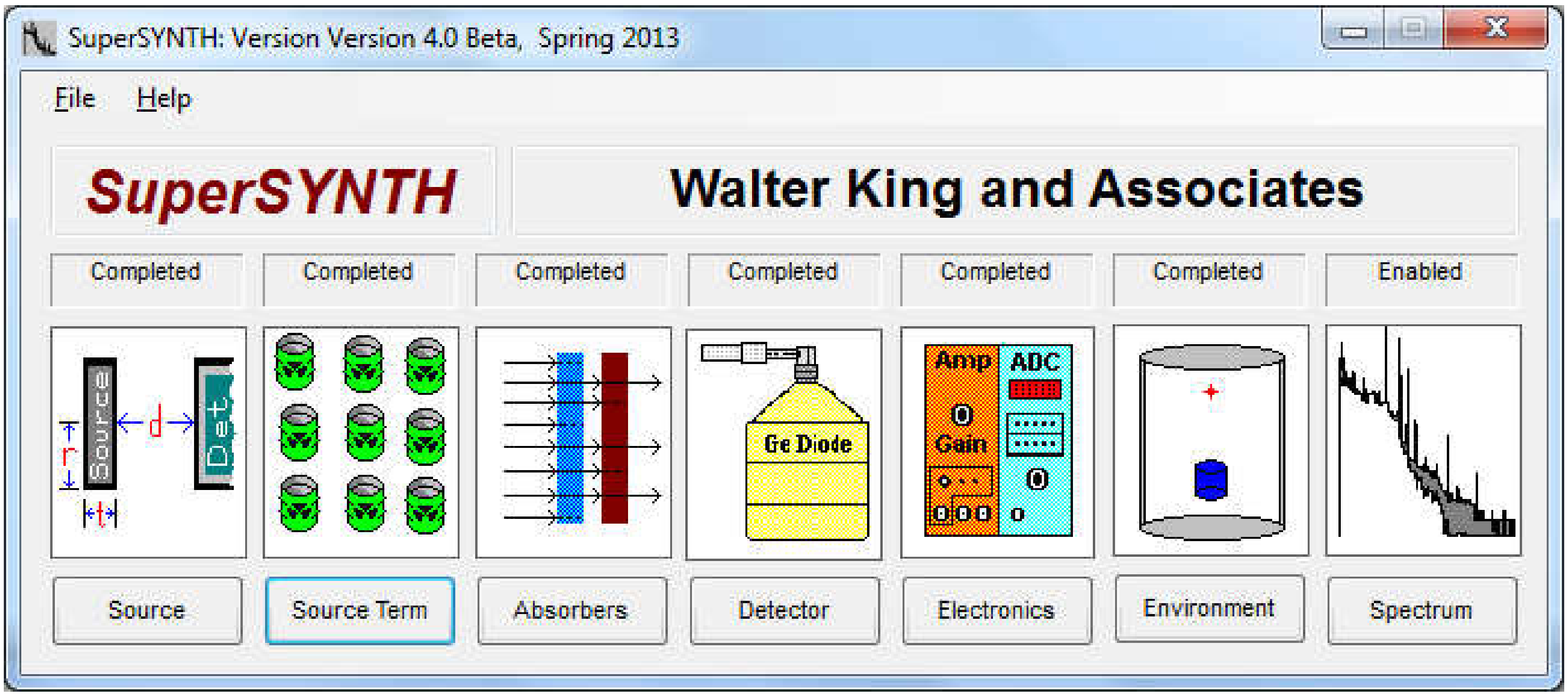
Super***SYNTH***

A Gamma-Ray Spectroscopy Interface to MCNP



Overview

What SuperSYNTH is and does

- A Gamma-Ray Spectroscopy Interface to MCNP designed to simplify modeling of laboratory and real world measurements

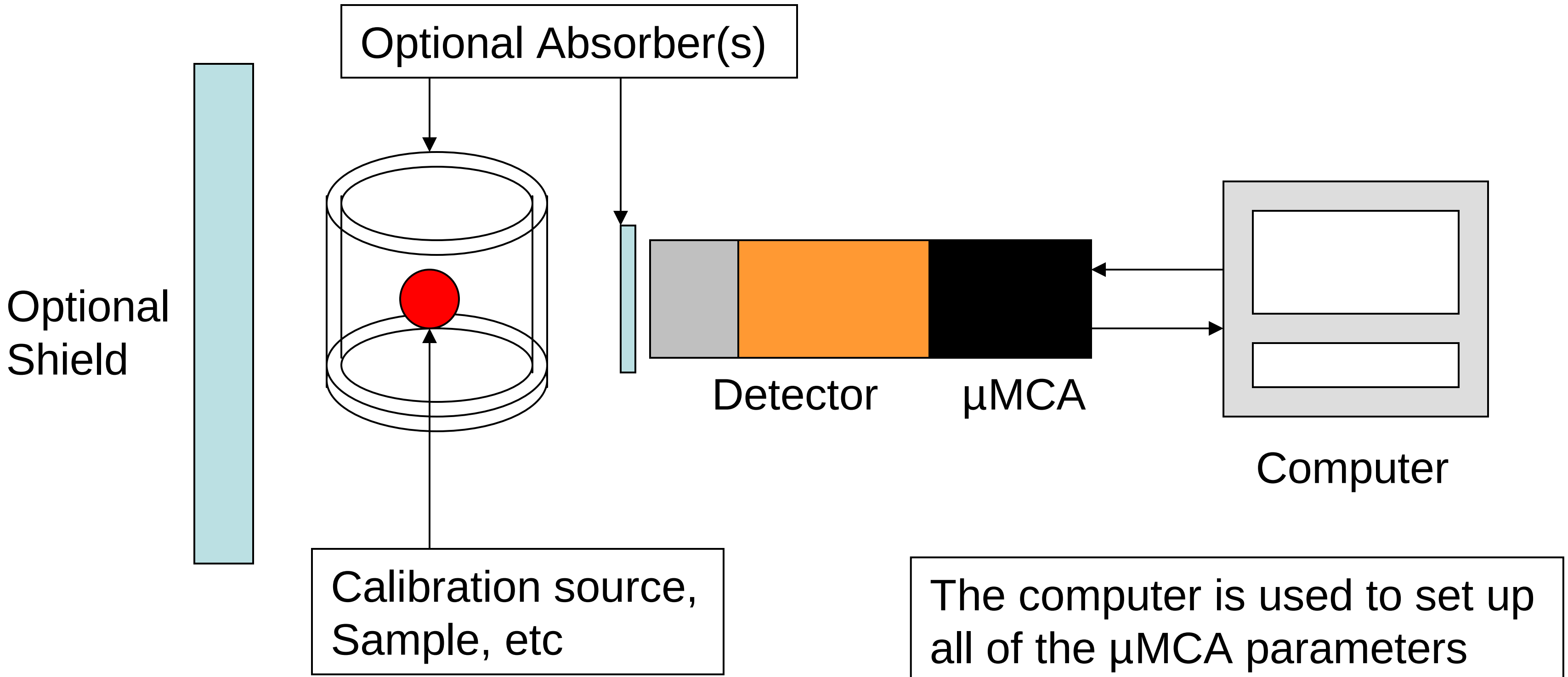
- Requires MCNP to be installed and functioning to generate spectra (doesn’t need MCNP if only generating an input deck)

- Organizes the problem into six logical steps

- Generates a fully commented and functional MCNP input deck

- Runs MCNP, then parses the generated mctal file to produce a spectrum that can be viewed and saved in a number of different spectral data formats

An Over Simplified Gamma-Ray Measurement



The computer is used to set up all of the µMCA parameters (energy calibration, count time, etc) and control the acquisition

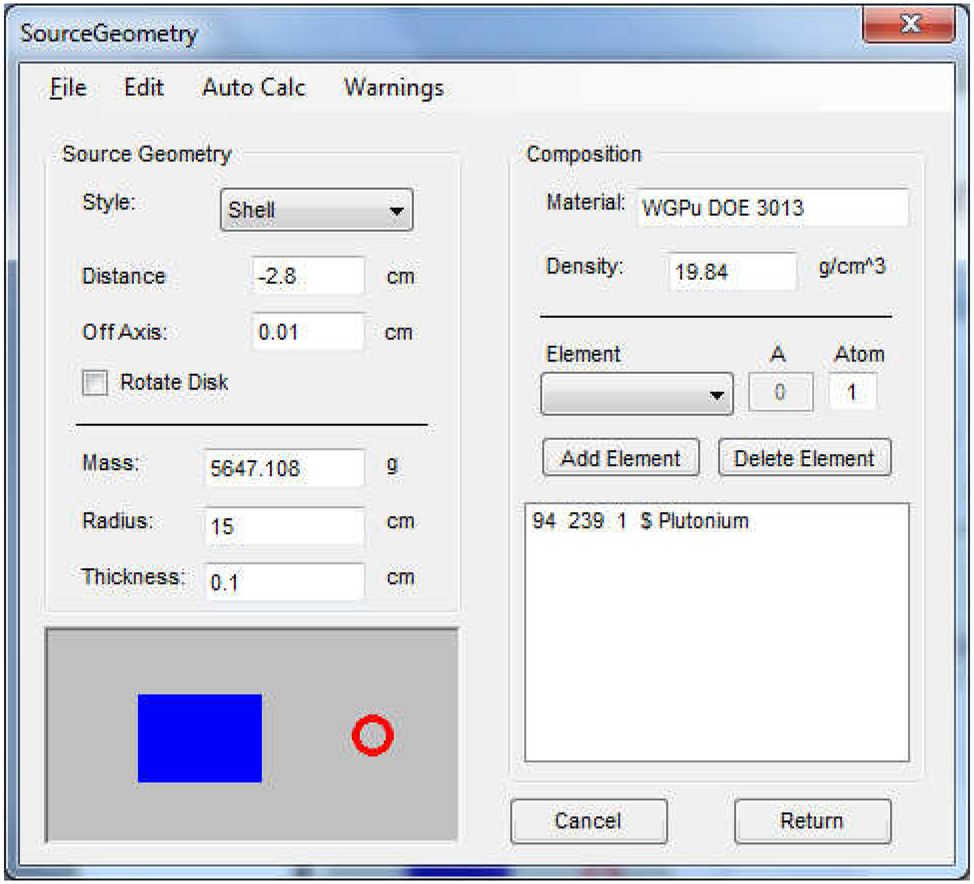
Six Easy Pieces

(With apologies to Richard Feynman)

- Source Geometry and Bulk Composition
- Source Term (^{241}Am, ^{137}Cs, ^{60}Co, etc)
- Absorbers (shape, location, composition, etc)
- Sensor (type, size, resolution, etc)
- Counting Parameters (energy calibration, etc)
- Counting Environment (shield)

=> MCNP => Generated Gamma-Ray Spectrum

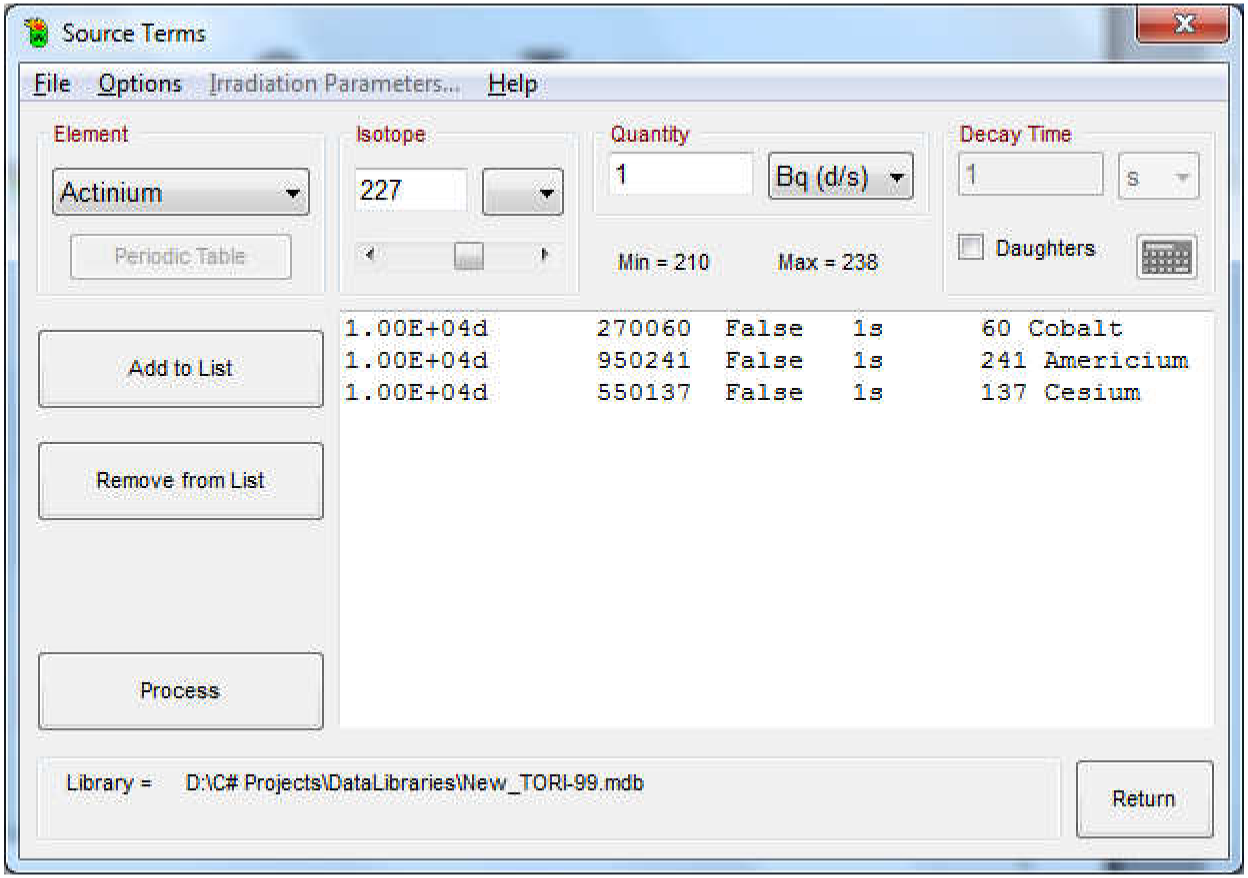
Source Geometry and Composition



Source Geometry

	Mass	Off-Axis	Edge-On
• Point		x	
• Sphere	x	x	
• Shell	x	x	
• Disk	x	x	x

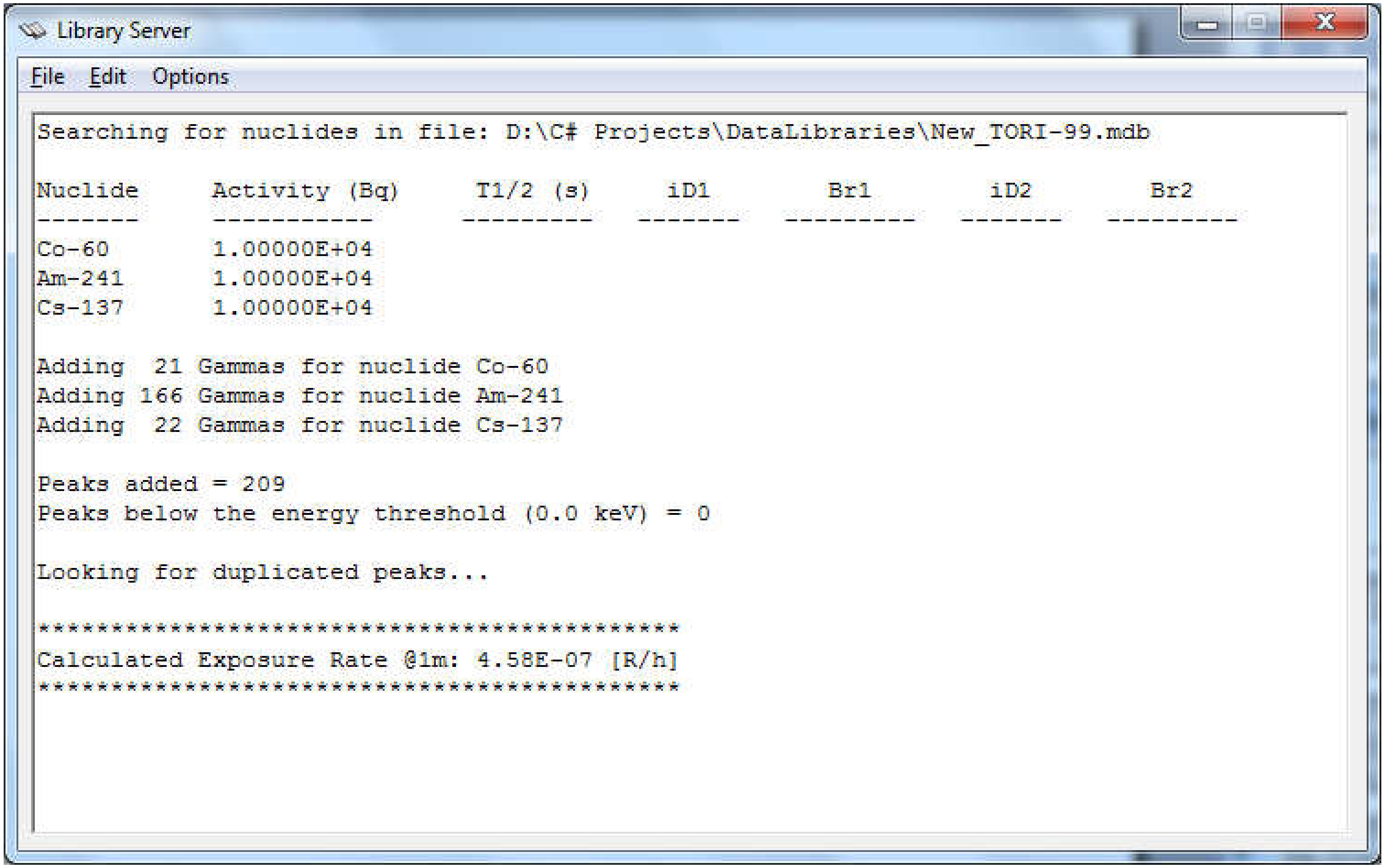
Source Term


Source Terms
File Options Irradiation Parameters... Help
Element
Actinium
Periodic Table
Isotope
227
Quantity
1
Bq (d/s)
Min = 210
Max = 238
Decay Time
1
s
Daughters
Add to List
Remove from List
Process
1.00E+04d 270060 False 1s 60 Cobalt
1.00E+04d 950241 False 1s 241 Americium
1.00E+04d 550137 False 1s 137 Cesium
Library = D:\C# Projects\DataLibraries\New_TORI-99.mdb
Return

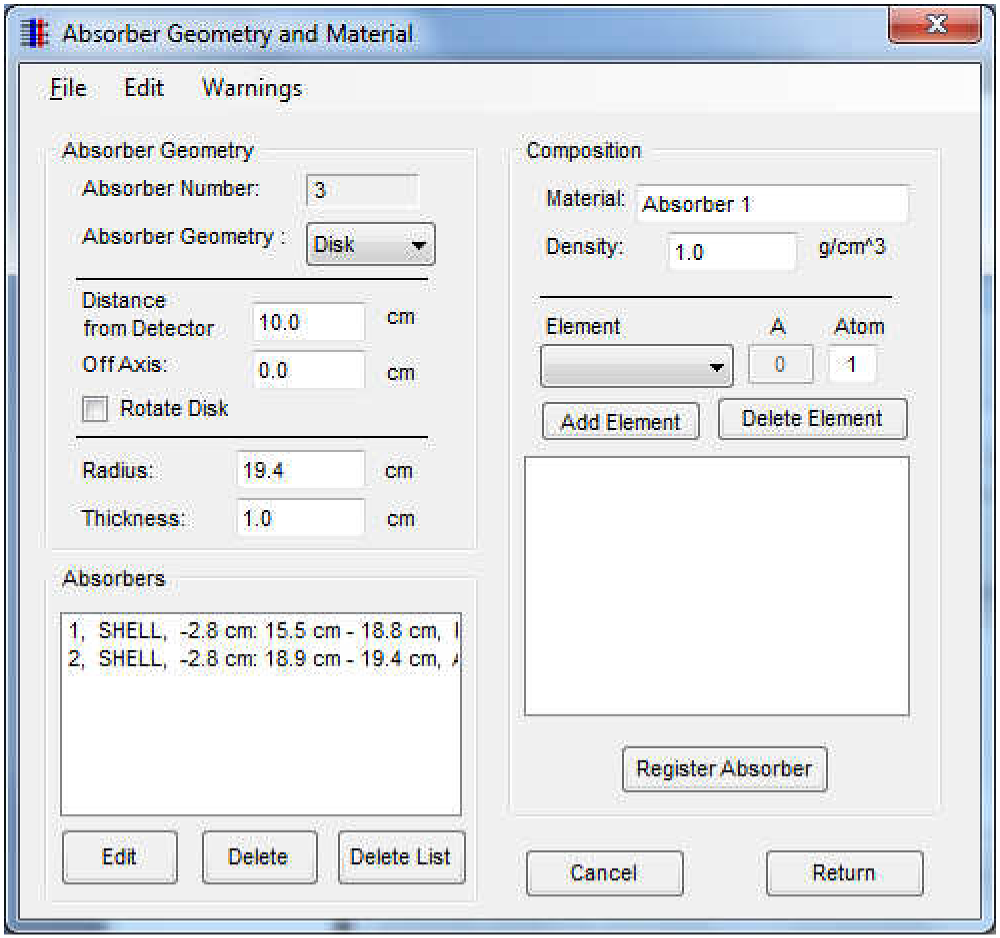
Gamma-Ray Data Libraries

- Enhanced TORI-99 (based on the LBL Table of Radioactive Isotopes compilation revised to 1999)
- PC_NuDat (based on the NNDC compilation revised to 2004)
- User Supplied (It's an open format that can implemented as a Microsoft Access or SQLite database

Library Server



Absorbers


Absorber Geometry and Material
File
Edit
Warnings
Absorber Geometry
Absorber Number:
3
Absorber Geometry :
Disk
Distance from Detector
10.0
cm
Off Axis:
0.0
cm
Rotate Disk
Radius:
19.4
cm
Thickness:
1.0
cm
Absorbers
1, SHELL, -2.8 cm: 15.5 cm - 18.8 cm,
2, SHELL, -2.8 cm: 18.9 cm - 19.4 cm,
Edit
Delete
Delete List
Composition
Material:
Absorber 1
Density:
1.0
g/cm^3
Element
A
Atom
0
1
Add Element
Delete Element
Register Absorber
Cancel
Return

Absorber Geometries

	Off-Axis	Edge-On
• Shell	x	
• Disk	x	x

Sensors

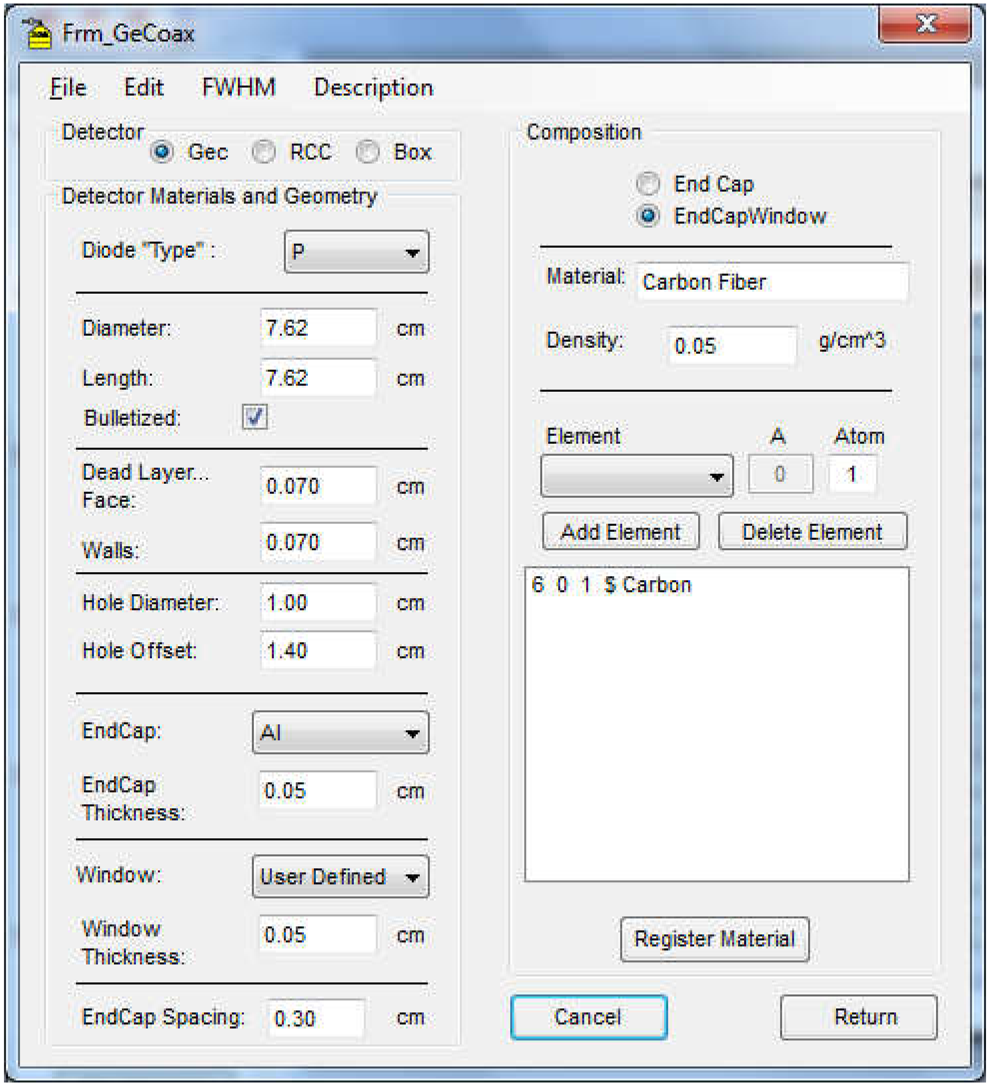
- Detailed High Purity Coaxial Ge (Gec)
- Generic Right Circular Cylinder (RCC)
- Generic Box (planar Ge, Large PVT, etc)
- The RCC and Box sensors may be any reasonable size and composition (there are a number of standard default compositions + user defined materials {Tomato Soup?})

Sensors

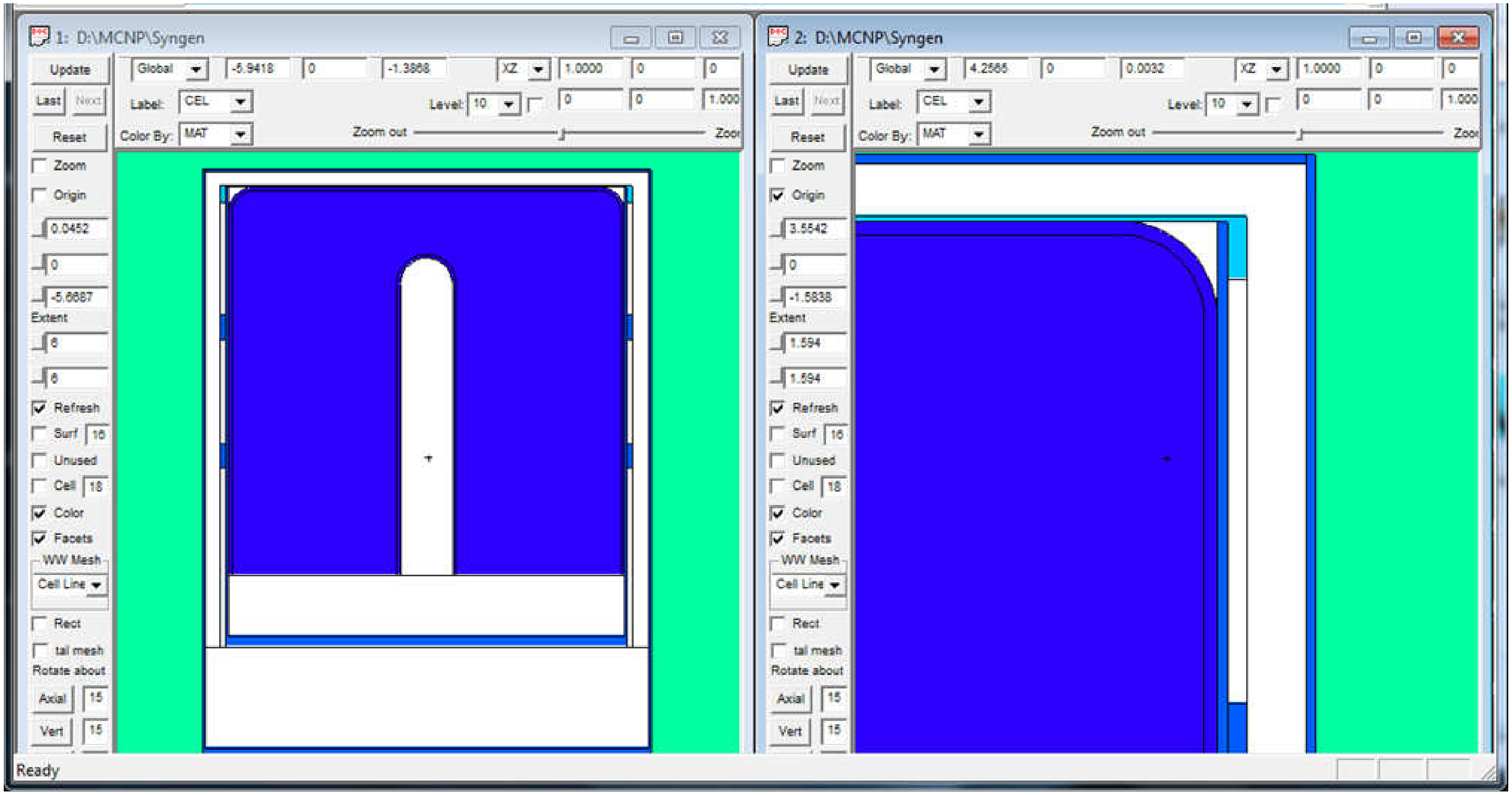
- Ge sensors have many adjustable parameters in addition to the crystal dimensions

- All three sensor types have a list of standard EndCap and Window materials and allow a “User Defined” material for either of these components

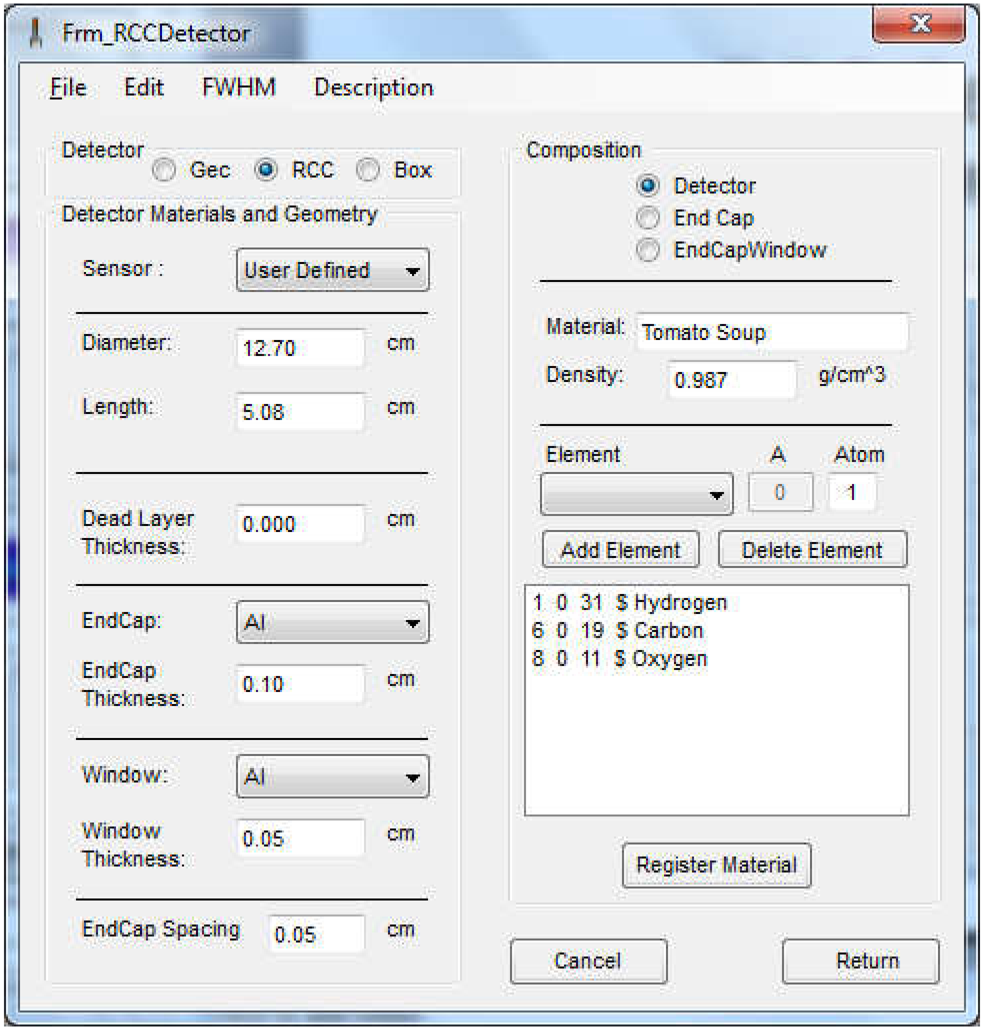
Germanium Diode



Germanium Diode Model

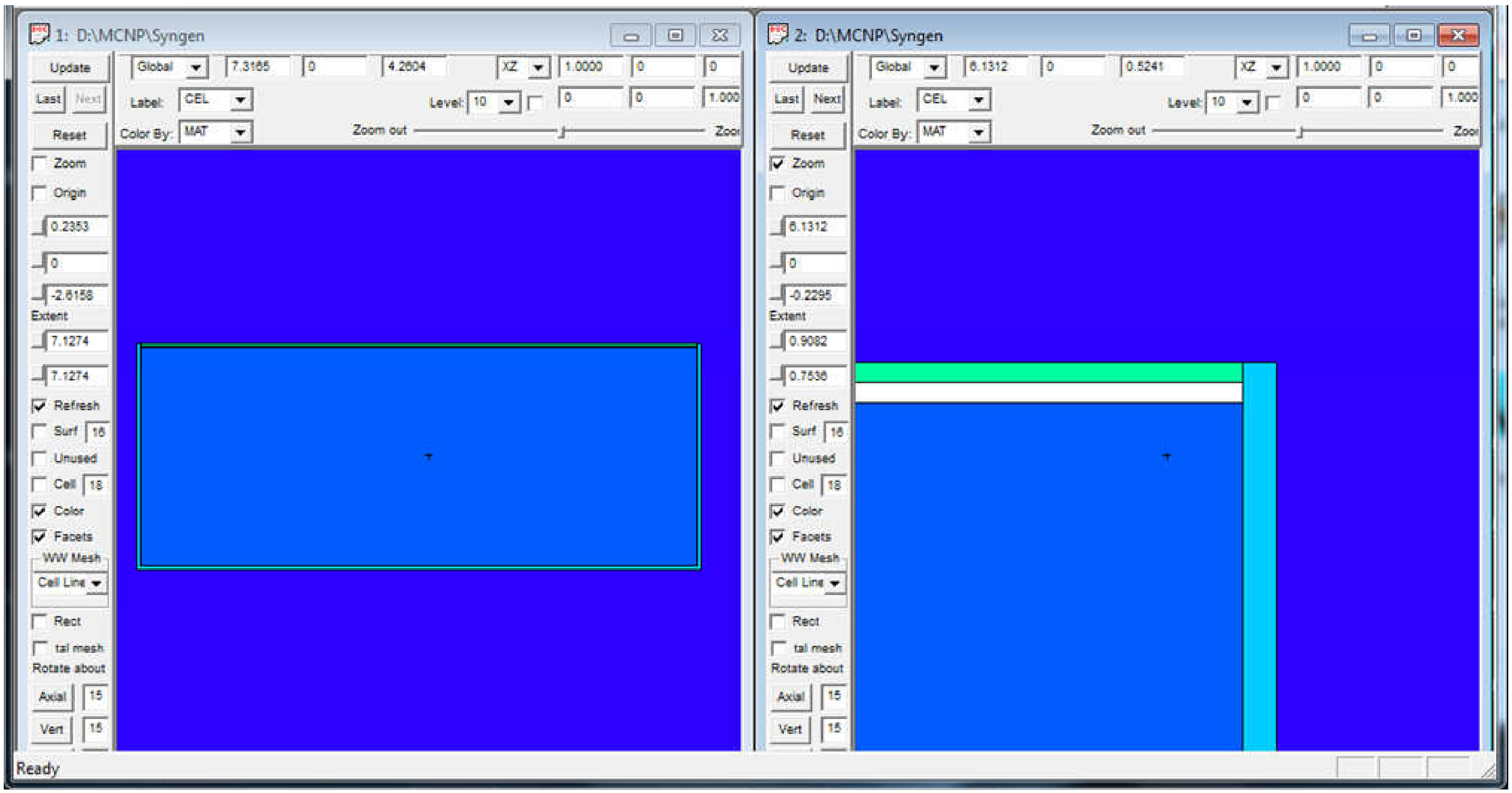


RCC Sensor

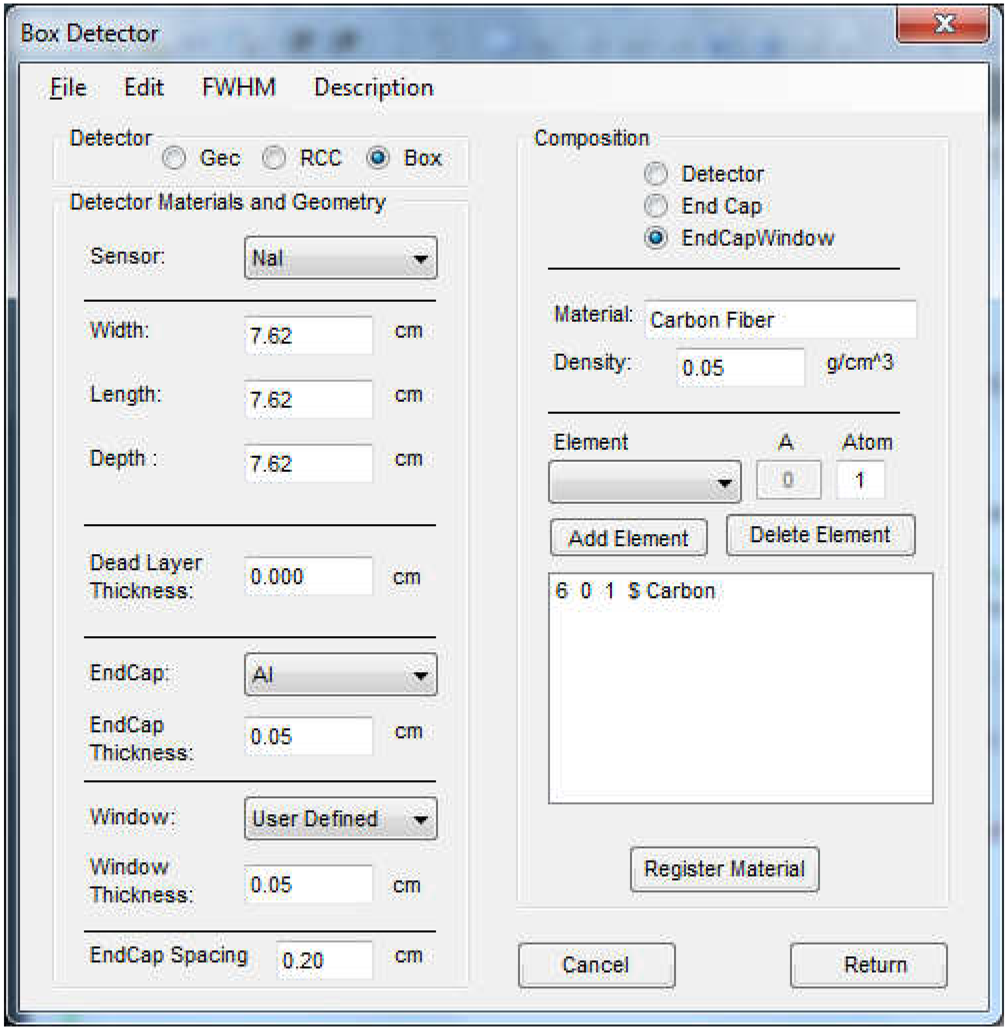


Frm_RCCDetector
File
Edit
FWHM
Description
Detector
Gec
RCC
Box
Detector Materials and Geometry
Sensor :
User Defined
Diameter:
12.70
cm
Length:
5.08
cm
Dead Layer Thickness:
0.000
cm
EndCap:
Al
EndCap Thickness:
0.10
cm
Window:
Al
Window Thickness:
0.05
cm
EndCap Spacing
0.05
cm
Composition
Detector
End Cap
EndCapWindow
Material:
Tomato Soup
Density:
0.987
g/cm^3
Element
A
Atom
0
1
Add Element
Delete Element
1 0 31 $ Hydrogen
6 0 19 $ Carbon
8 0 11 $ Oxygen
Register Material
Cancel
Return

RCC Sensor Model



Box Sensor


Box Detector
File
Edit
FWHM
Description
Detector
Gec
RCC
Box
Detector Materials and Geometry
Sensor:
NaI
Width:
7.62
cm
Length:
7.62
cm
Depth :
7.62
cm
Dead Layer Thickness:
0.000
cm
EndCap:
Al
EndCap Thickness:
0.05
cm
Window:
User Defined
Window Thickness:
0.05
cm
EndCap Spacing
0.20
cm
Composition
Detector
End Cap
EndCapWindow
Material:
Carbon Fiber
Density:
0.05
g/cm^3
Element
A
Atom
0
1
Add Element
Delete Element
6 0 1 $ Carbon
Register Material
Cancel
Return

Tools to make life a bit easier

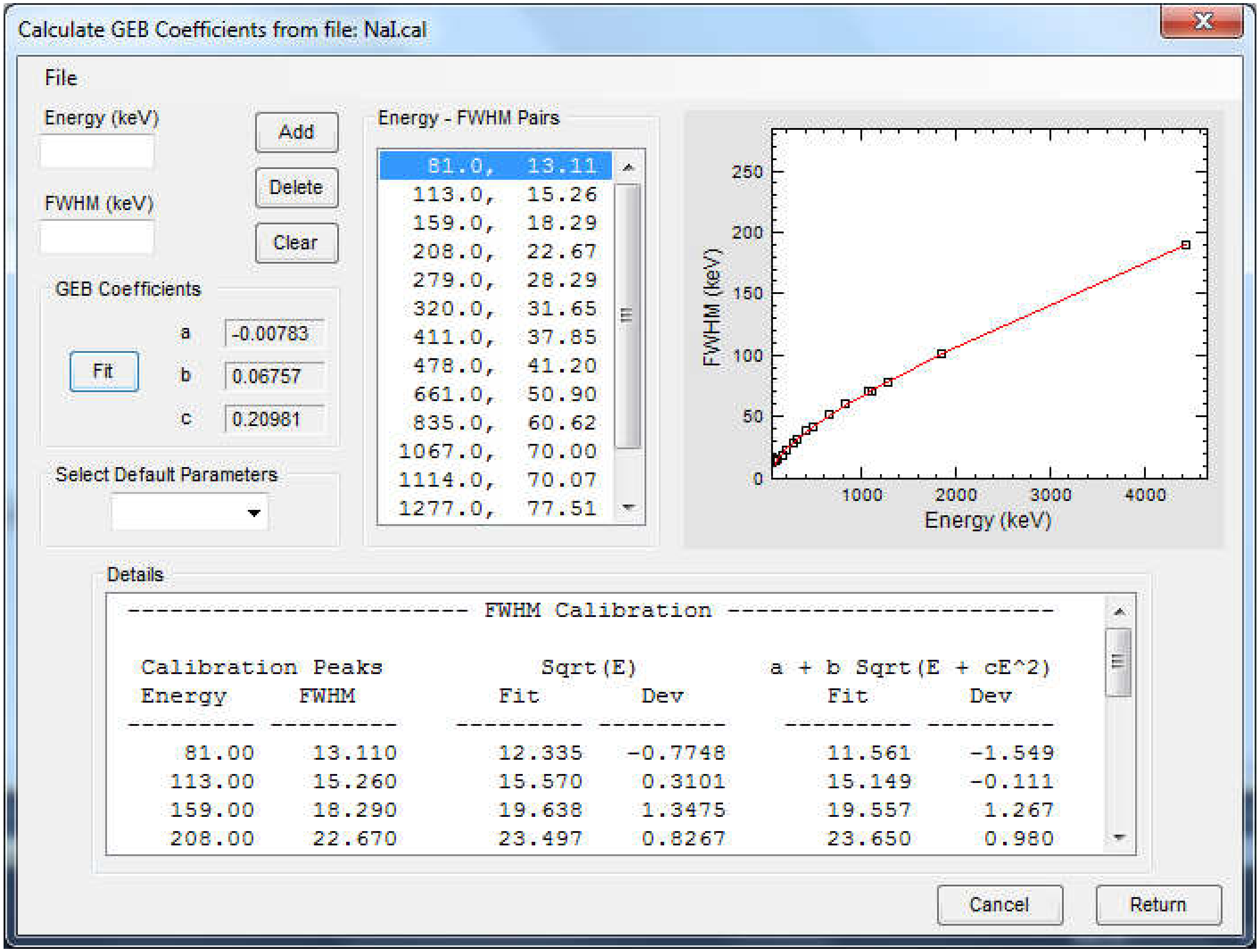
- GEB coefficient calculator to fit the MCNP Full Width at Half Maximum function

  $$FWHM = a + b*\sqrt{E + cE^2}$$

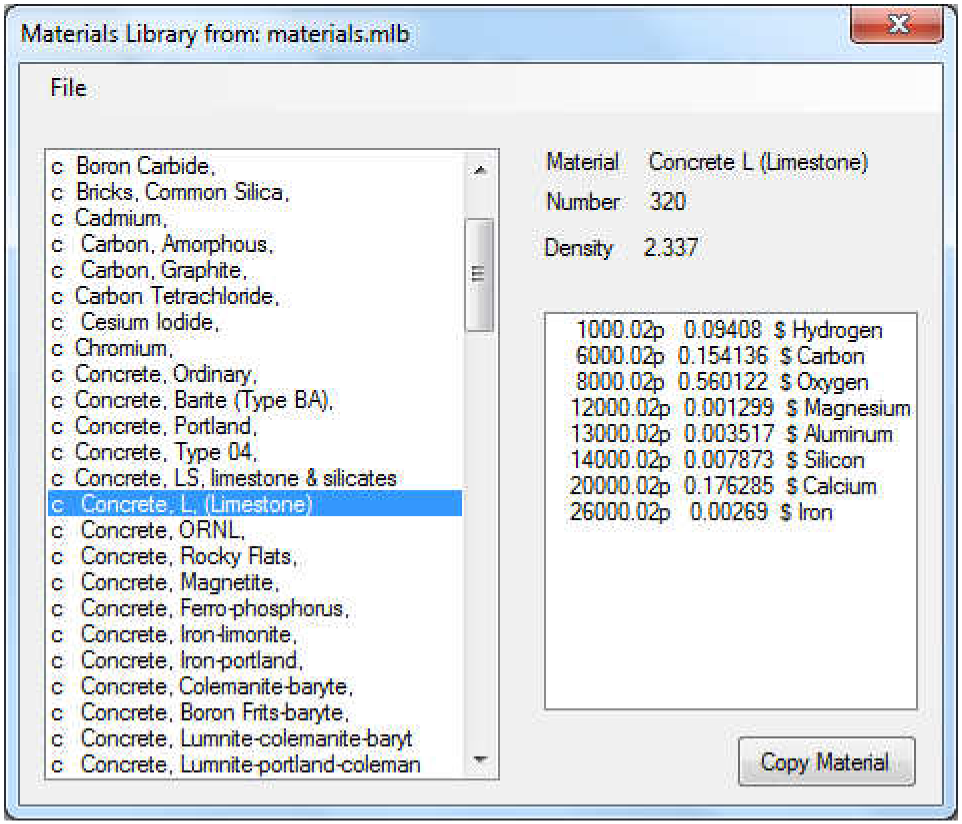
  to experimental data

- A Materials Library utility

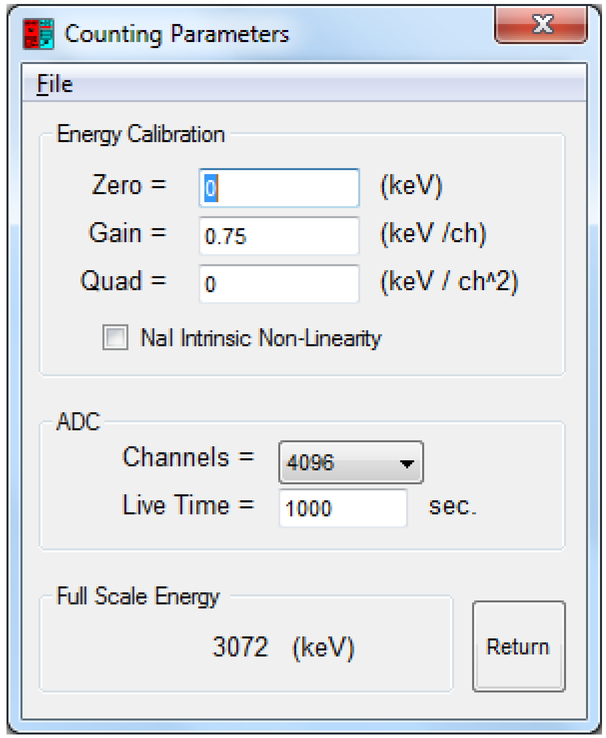
GEB Coefficient Calculator



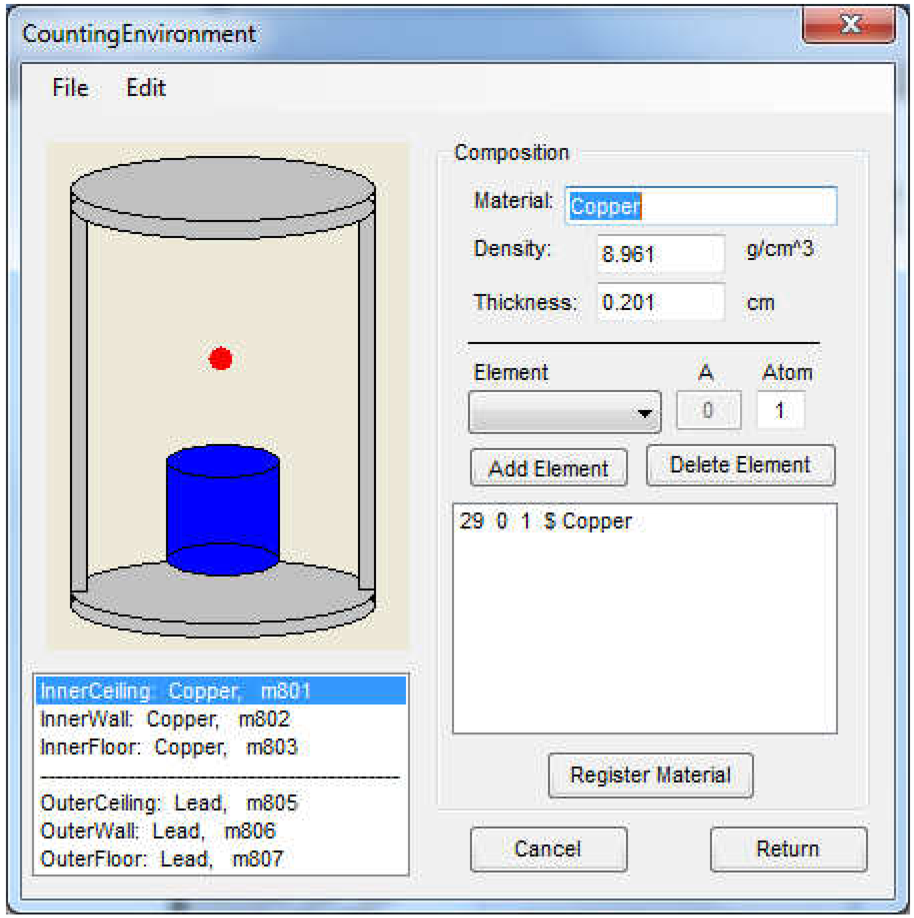
Materials Library Utility



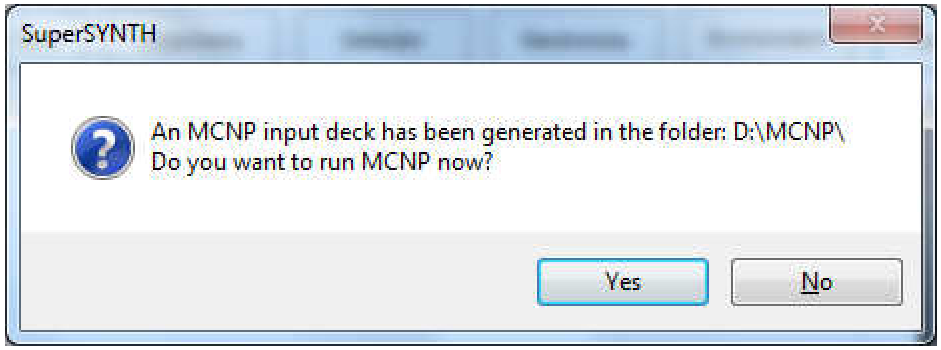
Counting Parameters



Counting Environment



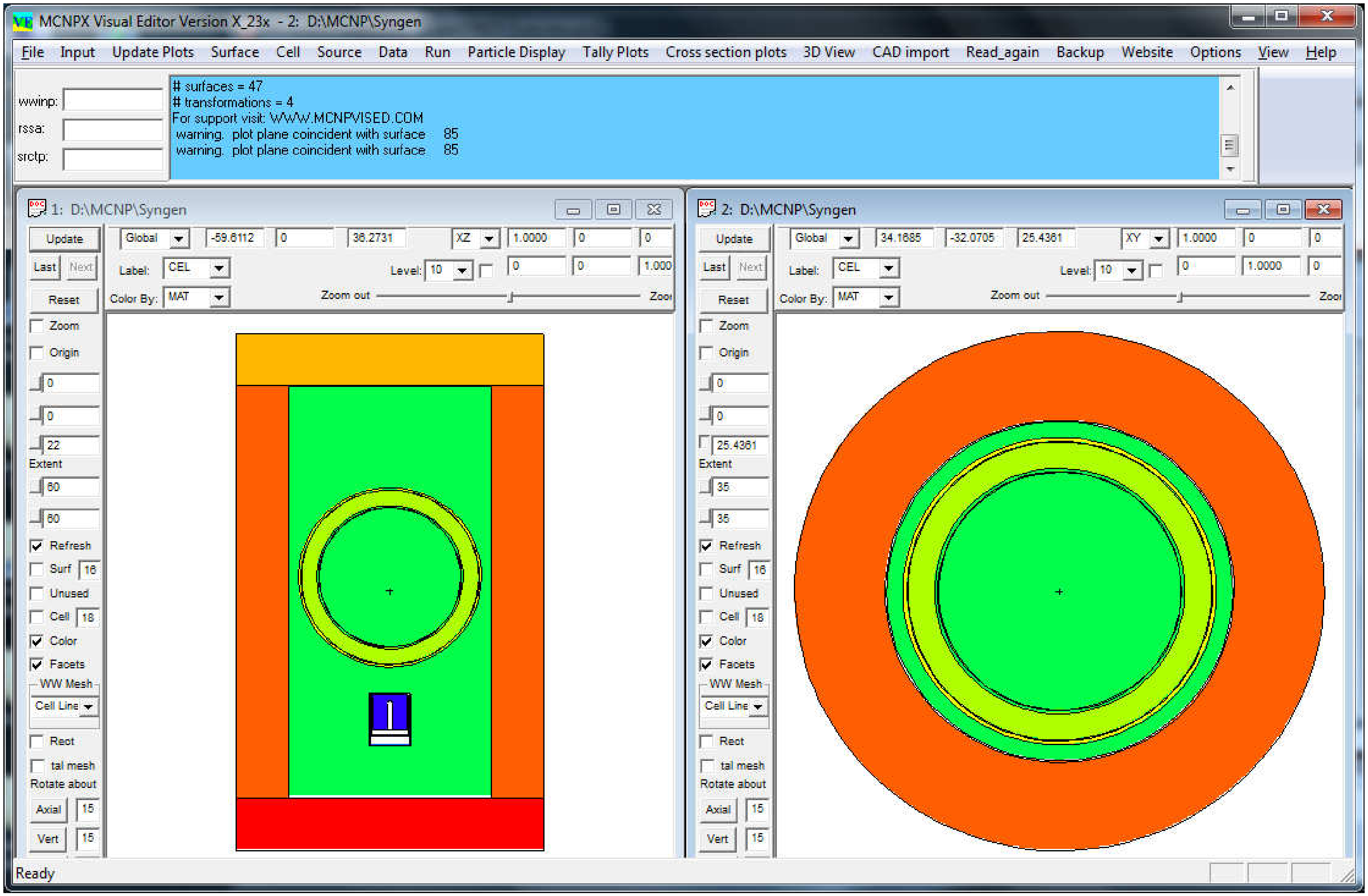
Generated Input Deck



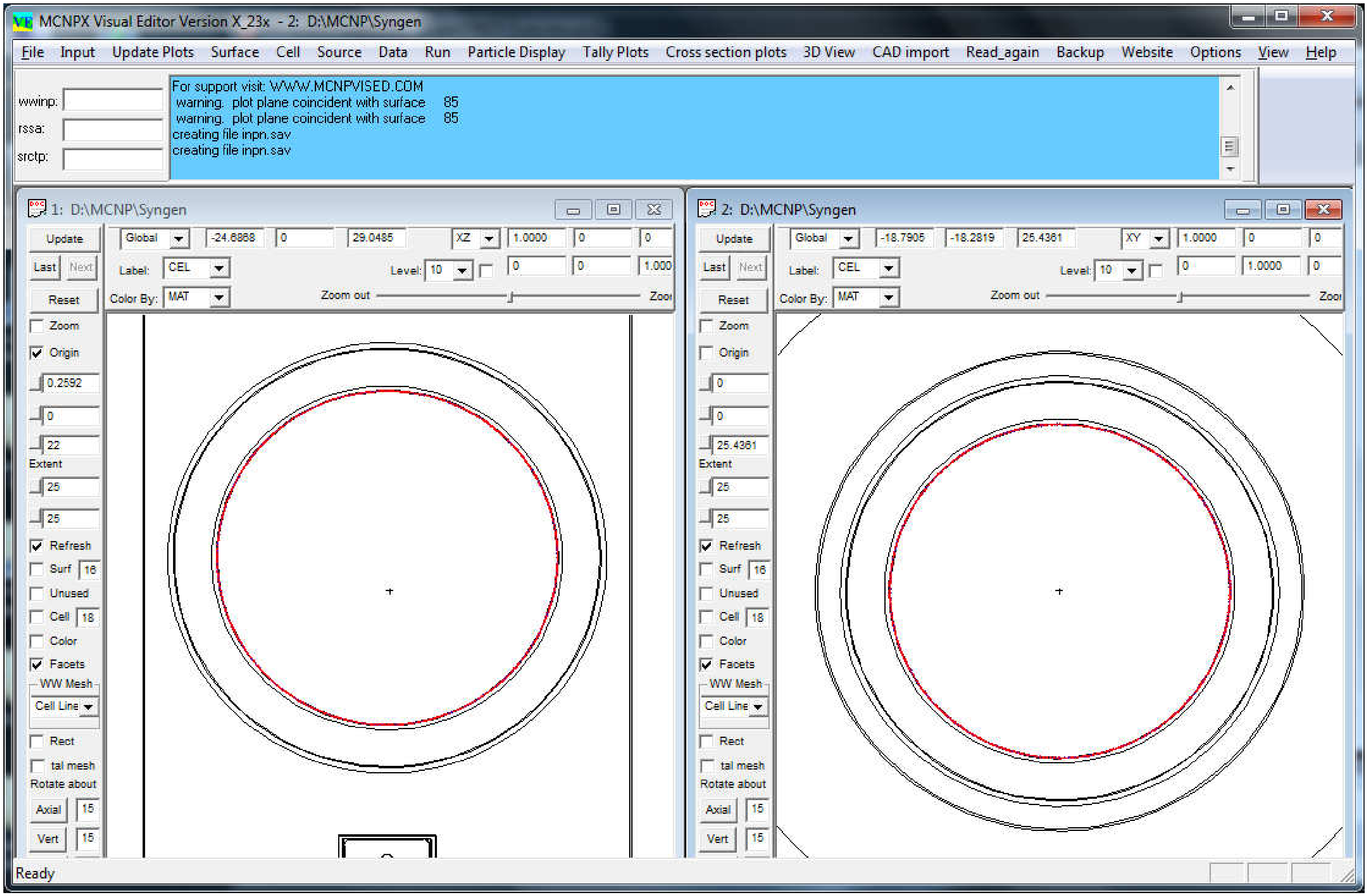
- All of the surfaces in the generated input deck are on translation cards so you can easily pull one or more components out of the model and reuse them in another project!

```
. . .
c
c Outer Shield
c
  906  4  cz     32.768 $ Outer Bounding cylinder
  907  4  pz     49.966 $ Outer Bounding top Surface
  908  4  pz     -45.570 $ Outer Bounding bottom Surface
c
c REQUIRED blank line to separate Surface cards from Data cards

c ******************************** Data cards ********************************
c
c
c Surface Translation Cards
c
c Translations to move detector and other elements to appropriate location and
c orientation. The detector, as defined above, is pointed in the +z direction.
c The translation cards below rotate the detector to be facing along different
c axes.
c
c       x  y  z   xx'  yx'  zx'   xy'  yy'  zy'   xz' yz' zz'
c *tr1  0  0 -8    0   90   90    90  180   90              $ rotate +z to -z
c *tr1 -4  0  0   90   90    0    90    0   90              $ rotate +z to -x
c *tr1  4  0  0   90    0   90    90   90    0              $ rotate +z to +x
c *tr1  0 -4  0    0   90   90    90   90    0              $ rotate +z to -y
c *tr1  0  4  0   90   90    0     0   90   90              $ rotate +z to +y
c *tr1  0  0  4                               $ no rotation, just translation
c
c The following translations are used in this model.
c
Tr1    0.0   0.0   0.0    $ Sensor
Tr2    0.0   0.0   0.0    $ Source
Tr3    0.0   0.0   0.0    $ Absorbers
Tr4    0.0   0.0   0.0    $ Environment
C
. . .
```

Check the Geometry



And the Source Location



Estimate MCNP Run Time

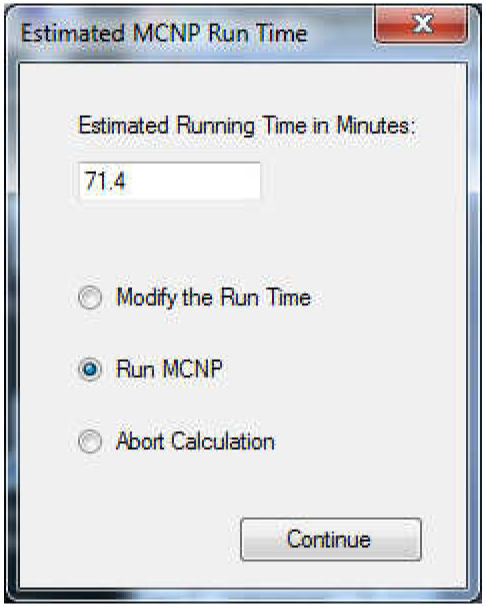
- Test run with nps 1000000

C:\Windows\system32\cmd.exe - mcnip.bat tester /c

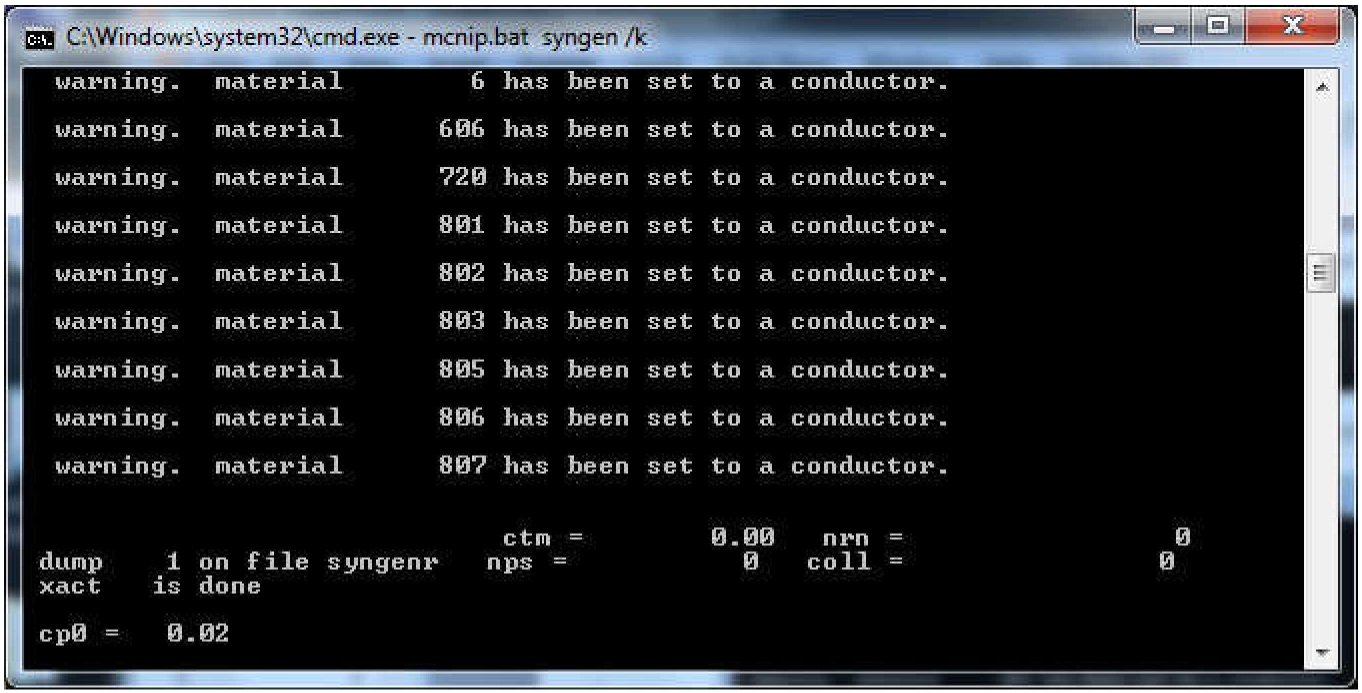
```
 warning.  material        6 has been set to a conductor.

 warning.  material      606 has been set to a conductor.

 warning.  material      720 has been set to a conductor.

 warning.  material      801 has been set to a conductor.

 warning.  material      802 has been set to a conductor.

 warning.  material      803 has been set to a conductor.

 warning.  material      805 has been set to a conductor.

 warning.  material      806 has been set to a conductor.

 warning.  material      807 has been set to a conductor.


                              ctm =        0.00   nrn =                 0
dump    1 on file testerr   nps =           0   coll =                0
xact   is done

cp0 =   0.02
```

MCNP Run Options

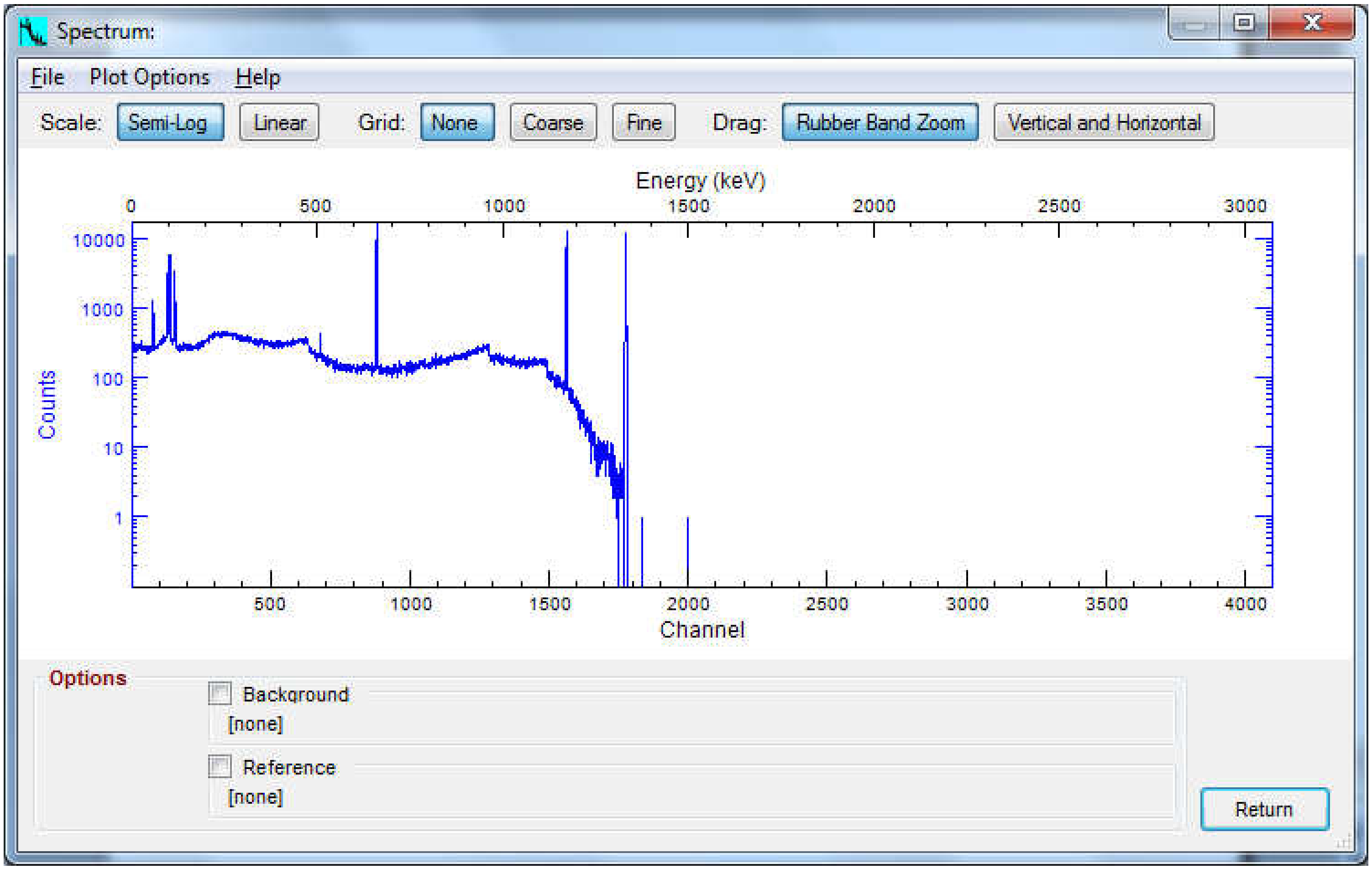
- Calculate the full run time and display some options



Running the Selected Option



View the Generated Spectrum



Break / Questions

Practical

- Source
  - Point, Volume
- Source Term
  - No decay, Decay
- Absorbers
- Detectors
  - Ge, RCC, Box
- Electronics
- Environment
- Spectrum Options